SIGNIFICANT HABITATS AND HABITAT COMPLEXES
OF THE NEW YORK BIGHT WATERSHED
Lower Hudson River Estuary
COMPLEX #21

I. SITE NAME: Lower Hudson River Estuary

II. SITE LOCATION: The lower Hudson River estuary is the portion of the Hudson River extending from the Battery at the southern tip of Manhattan north to Stony Point at the northern end of Haverstraw Bay.
TOWNS: Alpine, Edgewater, Englewood Cliffs, Fort Lee, Guttenburg, Hoboken, Jersey City, North Bergen, Tenafly, Weehawken, West New York, NJ; Bronx, Clarkstown, Cortlandt, Greenburgh, Haverstraw, Manhattan, Mount Pleasant, Nyack, Orangetown, Ossining, Peekskill, Stony Point, Yonkers, NY
COUNTIES: Bergen, Essex, NJ; Bronx, New York, Rockland, Westchester, NY
STATES: New Jersey, New York
USGS 7.5 MIN QUADS: Central Park, NY-NJ (40073-78), Yonkers, NY-NJ (40073-88), Jersey City, NY-NJ (40074-61), Weehawken, NY-NJ (40074-71), White Plains, NY (41073-17), Nyack, NY-NJ (41073-18), Ossining, NY (41073-27), Haverstraw, NY (41073-28), Peekskill, NY (41073-38)
USGS 30 x 60 MIN QUADS: Long Island West, NY-NJ (40073-E1), Newark, NY-NJ (40074-E1), Bridgeport, CT-NY-NJ (41073-A1)

III. BOUNDARY DESCRIPTION AND JUSTIFICATION: The significant habitat complex boundary for the lower Hudson River estuary follows the shores of the Hudson River from the tip of Battery Park, Manhattan, generally referred to as river kilometer 0 (river mile 0), north to the Stony Point area river kilometer 66 (river mile 41). The boundary of the complex includes all riverine and estuarine habitats, including open water and tidal wetlands in this stretch of the river. This section of the river is the major site of river water mixing with ocean water in the Hudson Estuary, and includes the moderate and high salinity zones (mesohaline and polyhaline salinity zones) of the river. This productive estuary area is a regionally significant nursery and wintering habitat for a number of anadromous, estuarine, and marine fish species, including the striped bass (*Morone saxatilis*), and is a migratory and feeding area for birds and fish that feed on the abundant fish and benthic invertebrate resources in this area.

IV. OWNERSHIP/PROTECTION/RECOGNITION: The uplands and shoreline are in a mosaic of private and public ownership. New York City owns a substantial portion of Manhattan's west side; much of the western shoreline of the Hudson from Fort Lee, New Jersey, north to Haverstraw, New York, is part of the Palisades Interstate Park system, including parts of Piermont Marsh in Tallman State Park. Underwater lands are also in public ownership, for example, New York City holds grants to most underwater lands to the pierhead limit; generally, the lands beyond this limit are under state ownership. The New York State Department of State has designated several Significant Coastal Fish and Wildlife Habitats within this stretch of the Hudson; these include Lower Hudson Reach, Piermont Marsh, Croton River and Bay, and Haverstraw Bay. Piermont Marsh has been designated by the National Oceanic and Atmospheric Administration and the New York State Department of Environmental Conservation as part of

the Hudson River National Estuarine Research Reserve. Wetlands are regulated in New York under the state's Freshwater Wetlands Act of 1975 and Tidal Wetlands Act of 1977; these statutes are in addition to federal regulation under Section 10 of the Rivers and Harbors Act of 1899, Section 404 of the Clean Water Act of 1977, and various Executive Orders.

V. GENERAL AREA DESCRIPTION: The Hudson River can be divided into salinity habitat zones based on average annual salinities: the polyhaline (high salinity) zone from Manhattan north to Yonkers; the mesohaline (moderate salinity) zone from Yonkers north to Stony Point; the oligohaline zone from Stony Point north to about Wappingers Falls; and the tidal freshwater zone from Wappingers Falls north to the Troy Dam (Table 21-1). These salinity zones vary greatly with the season, with the salt front pushed as far south as the Tappan Zee Bridge or upper harbor during high spring flows and brackish water extending as far north as Poughkeepsie during low summer flows. The Hudson River is partially regulated by the Hudson River-Black River Regulating District, one goal of which is to minimize spring flooding in the upper Hudson (above the Troy dam) and to provide some augmentation flows during the low flow periods. A secondary goal is providing freshwater flows during drought conditions to assist in keeping the salt front below the freshwater intakes at Poughkeepsie. The Hudson River estuary is a tidally dominated system with only an average of 10% of the total flow made up by freshwater inflows. Salinity influences the distribution and function of both plants and animals within the Hudson Estuary. The distribution of tidal marsh communities and plants in the Hudson is influenced by surface water salinity; freshwater tidal marsh communities generally occur north of Newburgh-Beacon and brackish tidal marsh communities generally occur south of Newburgh-Beacon. Benthic communities vary in distribution depending on bottom water salinity, with a typically marine benthos from Stony Point south dominated by marine worms and crustacea, a mixture of freshwater and marine organisms between Stony Point and Poughkeepsie, and freshwater snails, clams, chironomids, and insects present north of Poughkeepsie. Coastal and estuarine fish species tolerate a wide range of salinities. Anadromous fish species require different salinities at the different phases of their life cycles.

The lower Hudson River estuary zone from Manhattan to Stony Point is an area that approaches marine habitat characteristics, having very strong semi-diurnal (twice daily) tidal currents and moderate salinities generally in the range of 5 to 30 parts per thousand, but with lower salinities during spring runoff. This section of the Hudson is generally the zone of greatest mixing of river water and ocean water. The salt front where the ocean water and lower salinity river water meet also functions as a nutrient and plankton trap, making this zone of the river the most productive in terms of phytoplankton and zooplankton. During periods of high freshwater flow, much of the plankton is flushed out of the river; the exception is the shallow bays that trap some of the plankton. Plankton is also carried into the lower estuary with ocean waters on flood tide. High turbidity in this part of the estuary may limit primary productivity, with a range of sunlight penetration from one to five meters below the river's surface.

There are two distinct sections of the river within the lower estuary. The first, from the Battery at river kilometer 0 (river mile 0) to the New York-New Jersey state line at river kilometer 35 (river mile 22), is fairly narrow, with an average width of about 1,500 meters (5,000 feet), an average depth of about 12 meters (40 feet), and semi-diurnal tides of 1.2 to 1.5 meters (4 to 5 feet). There is only a narrow band of shallow subtidal flats along the shoreline. Most of the shoreline habitat, especially from Manhattan north to beyond Croton-on-Hudson, is extensively disturbed from industrial, commercial, and residential development that has bulkheaded and

filled substantial areas. An exception is the small natural shoreline and wetland complex at the mouth of the Spuyten Duyvil (Harlem River) at New York City's Inwood Hill Park. The shoreline in the lower 10 kilometers (6 miles) of the river is dominated by extensive pier, pile field, and interpier areas. Above Fort Lee, New Jersey, the western shoreline is dominated by a rocky talus slope shoreline at the base of the Palisades (see Palisades narrative, p. 528). The northern section of the lower estuary area from the state line north to Stony Point, river kilometer 35 to river kilometer 66 (river mile 22 to about river mile 41), includes the Tappan Zee, and Haverstraw and Croton Bays, and is known as the wide bays region. In this section, the river is much wider (to 5.6 kilometers [3.5 miles] wide) and shallower (1.8 to 3.6 meters [6 to 12 feet]), except for the 12-meter (40-feet) deep channel. In Haverstraw Bay the channel is maintained by dredging at a depth of 9.8 meters (32 feet). The lower estuary has only a few relatively minor freshwater tributaries: Sawmill River, Sparkill Creek, Cedar Pond Brook, Minisceongo Creek, and Furnace Brook. The only major tributary in this zone is the Croton River and its flow has been greatly reduced by impoundments for New York City's Croton Reservoir system. With the exception of Piermont and Grassy Point marshes and the mouth of the Croton River, there is a notable absence of marshes in this stretch of the river. The shorelines of the wide bays region support less intense development, a mixture of commercial and industrial uses, than does the lower section. There is one major power plant (Bowline) at the northern end of Haverstraw Bay and two other major power plants (Lovett and Indian Point) just north of Stony Point. There is an active landfill at Haverstraw and a recently capped landfill in Croton Point that has been turned into a park.

Piermont Marsh is a 405-hectare (1,000-acre) brackish wetland complex that includes a large brackish tidal marsh and adjacent intertidal mudflat grading into shallow subtidal aquatic bed. The brackish tidal marsh is dominated by common reed (*Phragmites australis*) and narrow-leaved cattail (*Typha angustifolia*), with some salt marsh species including smooth cordgrass (*Spartina alterniflora*), salt-meadow cordgrass (*S. patens*), spike grass (*Distichlis spicata*), and rose-mallow (*Hibiscus moscheutos*) and purple loosestrife (*Lythrum salicaria*). About 70% of the marsh is dominated by common reed. The mudflats are mostly unvegetated; the shallow aquatic system supports some submerged aquatic vegetation (SAV). Reported species include water celery (*Valisneria americana*), sago pondweed (*Potomogeton pectinatus*), and horned pondweed (*Zannichellia palustris*). The shallow water in Haverstraw Bay supports large areas of submerged aquatic vegetation, and Croton Bay historically had extensive submerged aquatic vegetation beds.

VI. ECOLOGICAL SIGNIFICANCE/UNIQUENESS OF SITE: The Hudson River is regionally significant as a productive estuary and is one of only a few major tidal rivers on the North Atlantic coast of the United States. The lower Hudson supports regionally significant fish populations as well as populations of wintering and migratory birds that feed on the rich fish and benthic resources. This is the primary nursery and overwintering area for striped bass in the Hudson River estuary, and striped bass from the Hudson account for an impressive portion of the total North Atlantic population. There are 240 species of special emphasis regularly using the lower Hudson River estuary, incorporating 151 bird species and 80 fish species, and including the following federally and state-listed species. (Living resources and their habitats are dynamic; therefore, the ecological significance and species information presented here may not be complete or up-to-date. State and federal environmental agencies (see Appendix III for office contacts) should be consulted for additional information.)

Federally listed endangered
peregrine falcon *(Falco peregrinus*)
shortnose sturgeon (*Acipenser brevirostrum*)
Federally listed threatened
bald eagle (*Haliaeetus leucocephalus*)
Federal species of concern[(1)]
northern diamondback terrapin (*Malaclemys t. terrapin*)
State-listed endangered - New Jersey
mud sunfish (*Acantharchus pomotis*)
cylindrical-headed bulrush (*Scirpus novae-angliae*)
State-listed threatened - New Jersey
osprey (*Pandion haliatus*)
State-listed threatened - New York
osprey (*Pandion haliatus*)
State-listed special concern animals - New York
banded sunfish (*Enneacanthus obesus*)

In the lower Hudson River estuary, primary production is moderate and zooplankton populations are extremely variable; both estuarine and marine forms occur. Copepods dominate the zooplankton community (Table 21-2); their density somewhat follows that of the phytoplankton, in that it decreases with increased distance from the New York - New Jersey Harbor. Meroplankton, those organisms that spend only part of their life cycle as plankton, e.g., benthic invertebrate larvae and fish larvae, dominate during the summer. In the estuary, meroplankton can range in abundance from 1,000 to 400,000 individuals per cubic meter, whereas copepod abundance can range from 1 to 90 individuals per cubic meter in the estuary. Shellfish species are abundant, including northern quahog (*Mercenaria mercenaria*), soft clam (*Mya arenaria*), and eastern oyster (*Crassostrea virginica*); however, the waters are not certified for human consumption of shellfish. The predominant crustaceans include grass shrimp (*Palaemonetes* spp.), sand shrimp (*Crangon septemspinosa*), and blue crab (*Callinectes sapidus*). Early life stage blue crab larvae require high salinities and, therefore, this is a prime adult blue crab spawning region.

Many marine spawners use the lower estuary as a nursery area; it provides an ideal habitat for the early critical life stages of these invertebrate and fish species. The lower Hudson River estuary is ranked among the most productive systems on the northern Atlantic coast for fisheries. Marine finfish that use this area include American eel (*Anguilla rostrata*), Atlantic menhaden (*Brevoortia tyrannus*), fourbeard rockling (*Enchelyopus cimbrius*), bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), northern pipefish (*Syngnathus fuscus*), and longhorn sculpin (*Myoxocephalus octodecemspinosus*). Estuarine fish that spawn in this stretch of the Hudson include winter flounder (*Pleuronectes americanus*), bay anchovy (*Anchoa mitchilli*), hogchoker (*Trinectes maculatus*), and mummichog (*Fundulus heteroclitus*); their young grow with the abundance of available food.

The **Lower Hudson Reach** extends from the tip of Manhattan upriver to Piermont Marsh. This stretch of the river is important wintering habitat for young-of-the-year, yearling, and older striped bass between mid-November and mid-April. These fish spawn upriver of Haverstraw Bay and utilize nursery areas in Haverstraw Bay and the Tappan Zee before moving down river to overwinter, generally feeding on the abundant invertebrates found in this area. Significant numbers of yearling winter flounder also occupy this stretch of the river in the winter. The New

Jersey Department of Environmental Protection and Energy conducted fish surveys of the Upper Bay of New York Harbor/Hudson River estuary and collected 23 fish species dominated by six species: bay anchovy, winter flounder, American shad (*Alosa sapidissima*), Atlantic tomcod (*Microgadus tomcod*), and alewife (*Alosa pseudoharengus*). Fish were most abundant in the spring and summer. Salinity varied over the year from 3 to 26 parts per thousand and temperature from 2.0 to 25.5°C (35.6 to 77.9°F). The area suffers from low dissolved oxygen (DO) concentrations; during the stratified spring and summer periods, bottom dissolved oxygens were 2.8 to 3.8 milligrams per liter (mg/l). It was theorized that fish utilize the area for shelter and reduced current velocities, and that adjacent shoal and pier structures may represent important juvenile feeding areas. In the New Jersey portion of the lower Hudson River to Piermont, 40 fish species and 26 invertebrates were collected. The abundant species collected throughout the area were alewife, American eel, American shad, Atlantic tomcod, bay anchovy, blueback herring (*Alosa aestivalis*), hogchoker, striped bass, white perch (*Morone americana*), and winter flounder. The area between Jersey City and Edgewater, river kilometers 2.4 to 14.2 (river miles 1.5 to 8.8), was found to be an important overwintering habitat for striped bass. Salinities ranged from 0 to 26 parts per thousand, and temperature from 2.0 to 28.0°C (35.6 to 82.4°F); dissolved oxygen was stratified throughout the area, with lower values in the bottom waters. Dissolved oxygen levels generally above 4.0 mg/l were observed; however, certain lagoon, interpier, and combined sewer overflow areas caused locally depressed dissolved oxygen. This stretch of the river has significant concentrations of wintering waterfowl, especially canvasback (*Aythya valisneria*), with lesser numbers of scaup (*Athya* spp.), mergansers (*Mergus* spp.), mallard (*Anas platyrhynchos*), and Canada goose (*Branta canadensis*). Bald eagles have recently been observed overwintering along the lower Hudson reach, with a roost site in the Palisades.

Piermont Marsh is located on the west side of the Hudson River at approximately river kilometer 40 (river mile 25). It is a sizeable intertidal brackish marsh community and one of the largest undeveloped wetland complexes on the Hudson. It includes the northernmost occurrence of salt marsh species on the Hudson. Because it represents an exemplary ecological community type, Piermont Marsh has been designated as one of four sites that make up the Hudson River National Estuarine Research Reserve. The diversity and abundance of fish and wildlife species are unusual in the lower estuary. Breeding birds known to use the marsh include Virginia rail (*Rallus limicola*), marsh wren (*Cistothorus palustris*), red-winged blackbird (*Agelaius phoeniceus*), and swamp sparrow (*Melospiza georgiana*). Other birds reported breeding here include black duck (*Anas rubripes*), gadwall (*Anas strepera*), wood duck (*Aix sponsa*), pied-billed grebe (*Podilymbus podiceps*) green-backed heron (*Butorides striatus*), American woodcock (*Philohela minor*), American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), sora (*Porzana carolina*), king rail (*Rallus elegans*), fish crow (*Corvus ossifragus*), and sedge wren (*Cistothorus platensis*). Concentrations of shorebirds, herons, and waterfowl use shallows and tidal flats as staging areas for both spring and fall migrations. Small numbers of osprey congregate in the marsh, especially during spring migration. Some limited anadromous and freshwater fish spawning and nursery habitat exists on Sparkill and Crumkill Creeks, and killifish and mummichog, as well as fiddler crabs (*Uca* ssp.) and blue crab, are abundant in the shallow and marsh areas. Diamondback terrapin have been known to nest on the small upland areas along the marsh and pier. Other resident wildlife species of Piermont Marsh include snapping turtle (*Cheldrya serpentina*), northern water snake (*Nerodia s. sipedon*), and terrestrial species such as raccoon (*Procyon lotor*), muskrat (*Ondatra zibethicus*), and mink (*Mustela*

vison). Rare plants include the state endangered cylindrical-headed bulrush and historical occurrences of necklace sedge (*Carex hormathodes*) and buttonbush dodder (*Cuscuta cephalanthi*).

Croton River and **Bay** are located on the east bank of the Hudson, at river kilometer 56 (river mile 35) between the towns of Cortlandt and Ossining, New York. The tidal portions of the bay and river form one of the largest sheltered shallow and mudflat areas in the main stem of the Hudson. This area once contained extensive beds of submerged aquatic vegetation and still has remnant submerged aquatic vegetation habitat. The Croton River drains approximately 970 square kilometers (375 square miles) and has an annual discharge rate of 14.1 cubic meters per second (500 cubic feet per second). The bay and river are productive year-round habitat for a number of freshwater and anadromous fish. These populations are important prey items to the state-listed threatened osprey, especially during migration periods. Bypassing barriers to fish passage on the river, coupled with minimum flow requirements, may significantly increase the habitat value of this already important site.

Haverstraw Bay and **Tappan Zee** occupy the area between Piermont Marsh and Stony Point. This wide, shallow section of the river is the area of the seasonal (and annual) salt front. This is the area where the fresh waters from the upper river mix with the marine water of the Atlantic, producing brackish water habitats in the 0 to 10 parts per thousand salinity range. Primary (submerged aquatic vegetation and phytoplankton) and secondary (zooplankton, invertebrates, and fish) biological productivity is very high in this extensive shallow water habitat, and the area serves as a major nursery and feeding area for anadromous and estuarine-dependent species. This area is a major nursery area for striped bass, white perch, tomcod, and Atlantic sturgeon that spawn elsewhere in the Hudson; it is, as well, a wintering area for the federally listed endangered shortnose sturgeon. This bay is critical habitat for the estuarine-dependent fish that the Hudson River system contributes to the New York Bight. Waterfowl use is extensive during the spring and fall migration periods for feeding and resting. Small numbers of wintering waterfowl include mallard, American black duck, Canada goose, mergansers, canvasback, common goldeneye (*Bucephala clangula*), and scaup. Peregrine falcons have consistently been using a nesting box on the Tappan Zee Bridge since about 1985, but have had low fledging success. A network of marshes behind Grassy Point adjacent to Haverstraw Bay is one of the few sizable marshes along the lower Hudson, but tidal circulation has been greatly reduced by the construction of roads and the marsh has been impacted by landfills and sewage treatment plants.

VII. <u>THREATS AND SPECIAL PROBLEMS</u>: All activities that degrade water quality in the lower Hudson River estuary affect the fish and wildlife that use this habitat for various life functions. Water pollution by toxics, chemicals, or oil, excessive turbidity, sedimentation, and nutrients from nonpoint source pollution all degrade the quality and functioning of this habitat. Leaching of toxics from the Croton Point landfill is a threat. Toxic contamination, through bioaccumulation and biomagnification, also carries with it long-term effects to the food chain and their possible effects on people. Habitat disturbance by human activities such as dredging and in-river and shoreside construction results in impaired water quality that has some impact on many species, including migrating species, using this estuary.

The use, especially nonconsumptive use, of fresh water can disturb the salinity gradients in the river. The effect is twofold; first, removing fresh water from the watershed and then, after it is used, discharging it into a higher salinity zone. This regime allows for the migration of the salt front much higher in the estuary, which is most evident during the summers of drought years,

although the migration of the salt front is regulated in part by releases at Stillwater/Great Reservoir. The natural salinity regime is important to maintaining habitat function and species diversity. Operation of water intakes also has significant impacts on fish populations through impingement of adults and juveniles, entrainment of critical egg and larval stages, and the release of warmer water.
The invasive species common reed and purple loosestrife dominate the two sizable marsh complexes at Piermont Marsh and Grassy Point in this stretch of the river. The exotic zebra mussel (*Dreissena polymorpha*) has displaced native species and greatly reduced phytoplankton populations in the mid and upper Hudson River estuary. This reduction in available primary production will likely impact fish and invertebrate populations in the lower Hudson River estuary.

VIII. CONSERVATION RECOMMENDATIONS: Water quality improvement efforts need to continue throughout the estuary. Upgrading sewage treatment facilities and controlling point and non-point source pollution should be major goals throughout the watershed. Dredging activities should consider spatial and temporal methods aimed at reducing potential impacts to the migrating fish populations and to nursery areas. Structural alteration of the habitat from filling and inwater structure construction poses significant impairments to the habitats and should be avoided. Further research on pier, inter-pier, and platform areas and their associated habitat values should be continued until we can fully understand the relationships of the river's physical environment, existing shoreline and inwater structures, seasonal temperature and salinity regimes, and the habitat values resulting from these interactions. The vulnerability of the entire area continues because of its desirability for development opportunity. Only comprehensive planning that recognizes the habitat values of this area, coupled with analyses of the impact to the habitat of individual proposals taken in the context of cumulative impacts, will result in balanced and effective protection of the estuary.
As one of four sites in the Hudson River National Estuarine Research Reserve, Piermont Marsh should be the focus of carefully monitored restoration efforts, including control of common reed and restoration of diamondback terrapin nesting areas.
As one of the few marsh areas in this stretch of the river, Grassy Point marshes should be a focus of restoration efforts through controlling landfill leachate, restoring tidal circulation, and controlling point and nonpoint source pollution to the tributaries (Cedar Pond Brook and Minisceongo Creek) feeding into the marsh.
Restoration and/or enhancement of the submerged aquatic vegetation beds in Haverstraw and Croton Bays would enhance the use of these bays as nursery areas. Restoration of former oyster beds in this section of the river through placement of culch (old shells or stones for a spawning bed) and seed oysters has been suggested as a way of restoring what was once an important part of the ecosystem.
The U.S. Army Corps of Engineers, in cooperation with the New York State Department of State and the New York State Department of Environmental Conservation, has a habitat restoration study and project underway in the Hudson River basin. This project should result in restoration of areas affected by past dredging projects, including improving circulation to tidal marsh areas, control and removal of exotic species, and creation of additional marsh areas. Fifteen sites were identified as a high priority for restoration as part of this study, including three sites in the lower Hudson: Piermont Marsh, Croton Bay to New York Harbor, and Spuyten Duyvil.
Increasing open space along the tributaries and along the Hudson as part of the Hudson Valley

Greenway and other efforts will both increase the riparian habitat and provide greater appreciation for this important resource.

The New York State Department of Environmental Conservation recently published an action plan for the Hudson River estuary that outlines priorities and actions needed for managing aquatic resources, preserving upland habitat, open space, and scenery, revitalizing the river-based economy through environmental protection, and promoting stewardship through partnership. Among the recommended actions are: increase monitoring of shad, striped bass, and sturgeon populations; standardize monitoring of fish entrainment and impingement at all power generation facilities to determine and regulate cumulative fisheries impacts; establish biocriteria for monitoring water quality in the Hudson; study the feasibility of restoring habitats at up to 15 locations; amend wetland regulations to more completely protect freshwater tidal wetlands; amend regulations to protect class C and D tributaries to the Hudson; conduct a biodiversity survey and recommend measures for protection; evaluate opportunities to transfer open space lands along the river with a target of 1,619 hectares (4,000 acres); promote the cleanup and appropriate reuse of abandoned and/or contaminated waterfront properties; and identify and quantify sources of contaminants of concern. These proposed actions should be fully supported by New York State and its partners.

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Table 21-1. Average locations of salinity zones in Hudson River

TYPE OF SYSTEM	ZONES	APPROXIMATE GEOGRAPHIC LOCATIONS	SALINITY
Riverine	Nontidal Fresh	Hudson and Mohawk Rivers at Troy, and above head of tide tributaries	0 ppt

Estuarine	Tidal Fresh	Troy dam to about Wappinger Falls and all Hudson tributaries to head of tide	0 - 0.5 ppt
		SALT FRONT / SALT WEDGE moves seasonally correlated to freshwater inflows	
Estuarine	Oligohaline	Wappinger Falls to Stony Point	0.5 - 5.0 ppt
Estuarine	Mesohaline	Stony Point to Yonkers	5.0 - 18.0 ppt
Estuarine	Polyhaline	Yonkers to Manhattan	18.0 - 30.0 ppt
Marine	Euhaline	Manhattan seaward Harbor Estuary	>30.0 ppt

Zooplankton in the New York Bight
Table 21-2. Salinity classification and location of common copepod species. after Malone (1977)

Species	Salinity Classification	Areas Found
Eurytemora affinis	e	E, IB
Eurytemora americana	e	E, BIS, IB,
Eurytemora herdmani	e	E, BIS
Acartia clausi	e-m	E, BIS, IB, OB
Acartia tonsa	e-m	E, BIS, IB, OB
Pseudodiaptomus coronatus	e-m	E
Oithona brevicornis	e-m	E, BIS, IB
Oithona similis	e-m	E, BIS, IB, OB
Tortanus discaudatus	e-m	E, BIS, IB, OB
Paracalanus crassiostris	e-m	E, BIS, IB, OB
Paracalanus parvus	eu-m	BIS, IB, OB
Pseudocalanus minutus	eu-m	E, BIS, IB, OB
Labidocera aestiva	eu-m	E, BIS, IB, OB

Temora longicornis	eu-m	E, BIS, IB, OB
Temora stylifera	eu-m	BIS, OB
Centropages hamatus	eu-m	E, BIS, IB, OB
Centropages typicus	s-m	E, BIS, IB, OB
Calanus finmarchicus	s-m	E, BIS, IB, OB
Aetideus armatus	s-m	OB
Clausocalanus pergens	s-m	OB
Gaidius tenuispinus	s-m	OB

e = estuarine E = estuary
e-m = estuarine - marine BIS = Block Island Sound
eu-m = euryhaline - marine IB = inner Bight
s-m = stenohaline - marine OB = outer Bight
1. [1]Species of special concern listed here include former Category 2 candidates.